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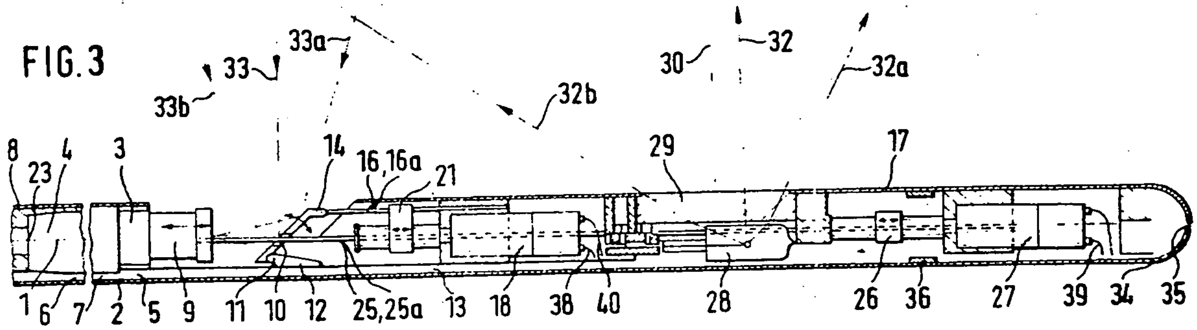
(54) Television camera for inspecting internal spaces in nuclear reactor plants

(57) A television camera for the inspection of the internal spaces in nuclear reactor plants has ultra-small dimensions, can be used at high temperatures and radiation loads during the shut-down period of the reactor for the inspection of internal spaces and is designed in such a way that it can easily be adapted to the given purpose of the inspection. This is achieved in that the camera (1) is housed in a tube (2) and is cooled, the objective lens (9) and/or the mirror (10) is/are connected to a (respective) motor (27, 18), and the light source (28) and the motor(s) (27, 18) are developed as separate components which may be assembled together in various combinations by the application of a modular assembly technique.

FIG.3



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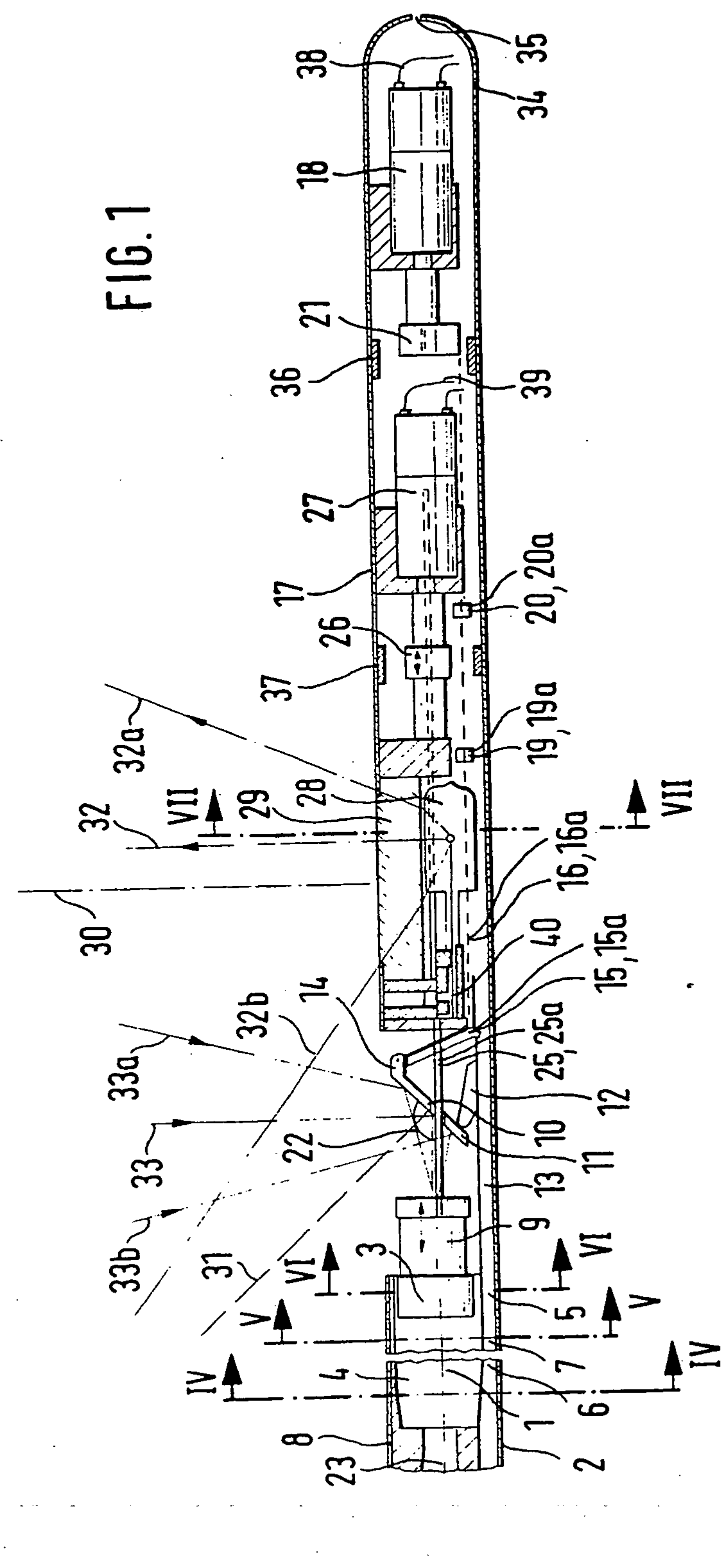

FIG. 1

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FIG. 2

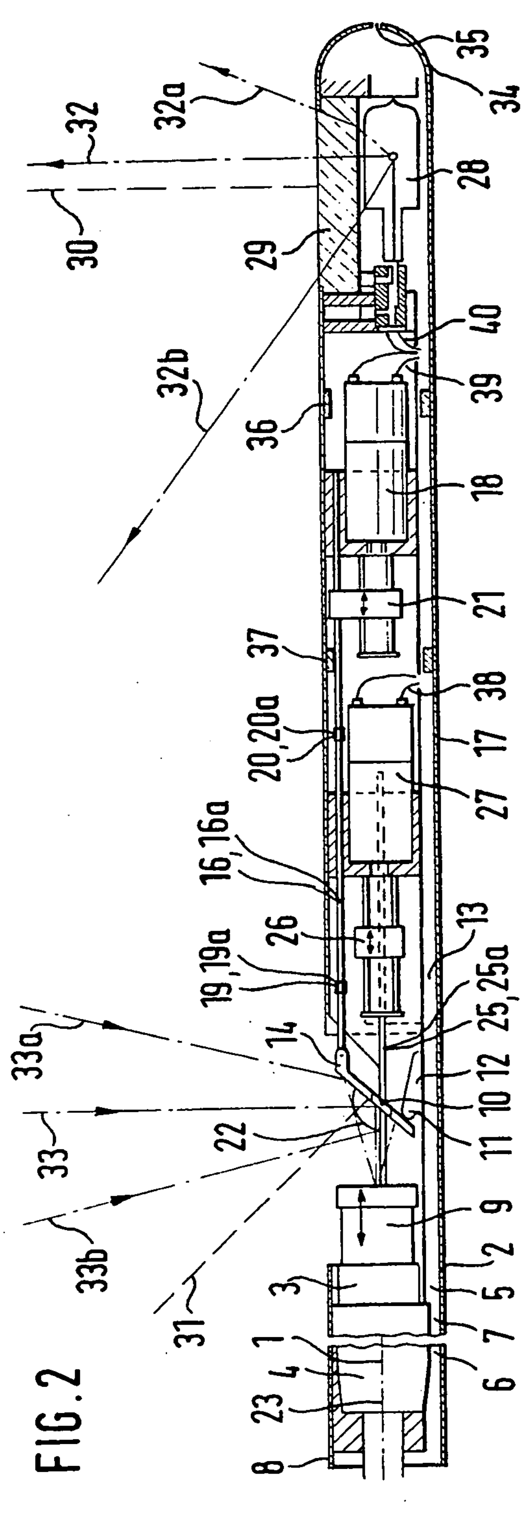
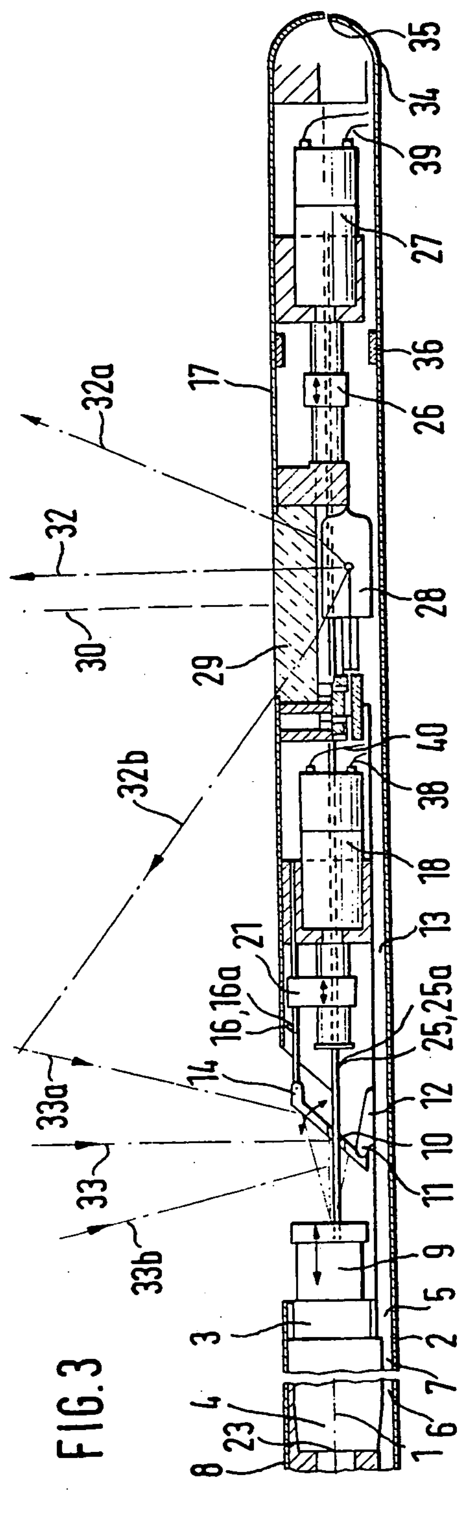


FIG. 3



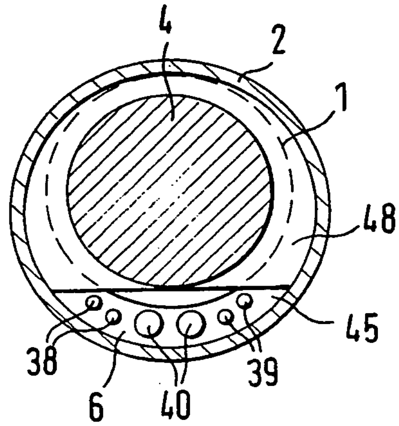


FIG.4

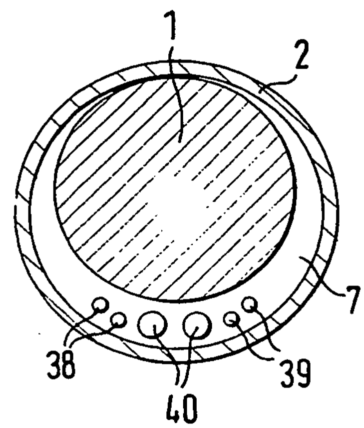


FIG.5

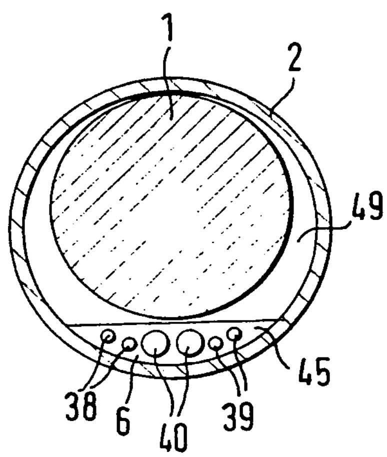


FIG.6

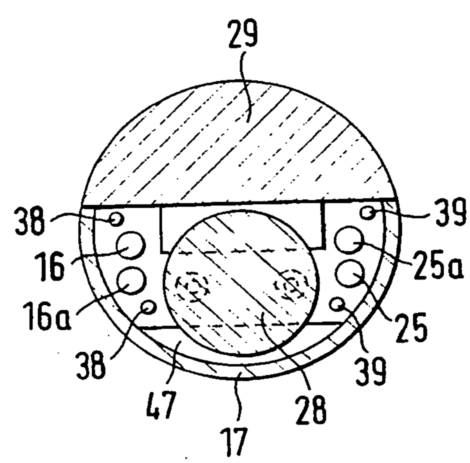


FIG.7

SPECIFICATION

Television camera for inspecting internal spaces in nuclear reactor plants

The invention concerns a television camera for inspecting internal space in nuclear reactor plants, particularly gas-cooled nuclear reactors, which is provided with a mirror and a light source in front of the objective-lens of the camera.

It is known to use television cameras for the inspection of activated internal spaces and other not easily accessible places in nuclear reactors, wherein the television camera is arranged at the end of a shaft or a manipulator, which crosses through penetration(s) present in the concrete wall of the reactor vessel, or through another opening and is controlled from the outside. The optical data gathered by the camera and related to technical conditions of the localised region or the individual constructional parts of the reactor are electrically or electromagnetically transmitted to a playback or reproducing unit disposed outside the reactor and then evaluated. A camera of this design is applied preferably in repeated examinations wherein the camera is positioned inside the nuclear reactor only during control. After completion of the control (test) it is removed therefrom and is decontaminated. To obtain good information values from the controls to be carried out, certain steps are taken before the reactor is put into operation which enable the simple determination of changes appearing in the more important components of the nuclear reactor. The method of comparing "before" with "after", wherein the arrangement or the construction of the individual components of the reactor before the reactor was put into operation is compared with the arrangement or construction of these components during recurring tests has given entirely satisfactory results. The changes ascertained are indicative of the extent of damage. Here, e.g. the steam generator is provided with a mark, the position of which in relation to the inner wall of the reactor vessel or to a certain spot of the inner wall, is fixed, the mark being located in the field of view of the camera used for the testing. The changes in the technical condition of the steam generator, e.g. during mounting, are clearly shown by the shifting of the position of the mark. It is also desirable to be able to inspect a large part of the internal space with only one camera, which is suitable by virtue of its design for more than a single particular test but for a number of various inspections.

The task underlying the invention is to provide a television camera for the inspection of internal spaces in nuclear reactor plants which has ultra-small dimensions, can be used at high temperatures and radiation loads during shut-down period of the reactor for the inspection of its internal spaces and is constructed in such a way that it may readily be adapted to the actual purposes of the inspection.

According to the invention, this task is achieved in that the camera is arranged in a tube and is cooled, the objective-lens and/or the mirror is or are connected with a, or a respective, motor and the light source and the motor(s) are developed as separate components which can be joined together in various combinations by the application of a modular assembly (building block) technique.

The invention starts from the fact that a per se known and commercially available small camera may be fully used for the inspection of internal spaces of nuclear reactors if conditions are created in which the negative effects of high temperature and pressure acting on the camera are eliminated or minimized, the camera being provided with additional components which take into account the actually employed inspection process, thus simplifying the examination.

According to the invention, the camera is arranged in a tube to which it is rigidly connected. The rigid connection is achieved by two ecccentric rings arranged at the near and far ends of the camera, respectively, the inner diameter of these rings corresponding to the diameter of the camera while the outer diameter corresponds to the inner diameter of the tube. The rings separate segments of the tube. By separating segments at the rings passageways are created between the camera and the tube which serve for conveying the gas required for cooling and for guiding electric cables. In addition, due to the arrangement of the rings on the camera, a gap is formed between the tube and the camera which serves for subjecting the camera to cooling gas. At the end of the tube another extension tube is joined to the tube to connect the camera to a manipulating device and to serve as a gas supply duct. A pivotable mirror is arranged in front of the objective lens of the camera which projects from the tube, the mirror being linked via a protrusion and a pivot pin to the tube extension, and its other end is connected via another pivot pin and two connecting rods to a motor for the mirror. When the motor is switched on, the axial movement of the rods is transmitted to the mirror whereby the angle between the main axis of the camera and the mirror surface will be increased. The same is true when the motor is reversed, but in this case the rods are moving in opposite directions and the angle decreases. It is desirable that the angle should be changeable slowly and continuously. Therefore the connecting rods are operated by the motor via a transmission gear. Knowing the relation between the number of the rotors and their r.p.m. and the change in angle, it is possible to determine the angles at any given

time. This fact is important inasmuch as it enables the reactor to be monitored through the inspection regions to which no other kind of access is possible during the whole operating time of the reactor, and the images recorded or appearing on a monitor (screen) may only be by comparison and computation. Angles smaller than 90° and larger than 170° should not be considered because in this domain of angles no useful mirror reflections of the monitored area or zone of the reactor can be obtained.

The sharpness of the image (definition) of the picture appearing in the monitor may be adjusted by an axial movement of the objective lens. The problem of the movement of the objective is solved in the same way as that of the movement of the mirror, i.e. by an objective-motor connected via two rods to the objective. When the objective motor is switched on or reversed, the objective moves axially in one or the other direction. It is expedient to construct the connecting rods for the drive of the mirror and the objective lens as one-piece components that can be linked together via couplings.

Due to the arrangement of the light source behind the mirror, according to the invention, a direct illumination of the objective from the light source is impossible and only reflected light falls on the objective which is then guided from the inspected zones of the reactor to the objective lens. The internal construction of the reactor, particularly the zones subjected to recurrent inspections, set high demands on the quality and intensity of the light source. Good illumination can be achieved by application of a miniature halogen lamp, wherein the whole lighting equipment consists additionally of a circular or parabolic, polished reflector and a condenser lens.

The individual components of the television camera are housed in a tube and tube extension and, according to the invention, these components are developed as separate independent component units which can be assembled together in various combinations by the application of a modular (building block) assembly technique, wherein the tube extension is connected to the tube via a channel and is provided at its end with an inlet for cooling gas. The modular construction of the individual components permits the television camera, particularly the lighting equipment together with the objective-motor and the mirror-motor to be matched optimally to the given purpose of the inspection. For example, when gaps or fissures and narrow zones of the interior of the reactor are to be inspected, it is advantageous to arrange the light source close to the mirror because in an extreme case it could happen that the spots it is desired to inspect are not illuminated at all. In arranging the individual components of the television camera disposed in the tube extension, one starts by considering the purpose of the actual inspection. The television camera is so arranged on a shaft and at the end of a manipulator as to permit radial movement of the camera. If certain locations are to be inspected e.g. the liner or the pebble draw pipe, it is again expedient to arrange the light source at the end of the tube extension.

The whole plant is supplied with electric current and is subjected to cooling gas. The supply of cooling gas takes place through an additional pipe which is connected to the end of the tube that surrounds the camera and provides the latter with cooling gas via a channel for cooling gas and for the electric cables extending into the tube extension, and leaves it at its end via a cooling gas outlet into the interior of the reactor. Electric cables for the current supply of the light source and the motors run through the gap and the cooling gas channel to the corresponding components.

The particular advantages of the invention are that by using the proposed camera an efficient, compact, space-saving, economical easily operated and versatile inspection apparatus is provided which may easily and simply be adapted to a given purpose of inspection.

According to the invention a camera for the inspection of the interior of nuclear reactor plants consists essentially of a camera arranged in a tube and provided with an integrated unit fitted in front of the objective lens of the camera, by means of which the optical efficiency of the camera is considerably improved.

Preferred embodiments of the invention are described with reference to the accompanying drawings, wherein:

Figure 1 shows a camera in a cooling pipe provided with a plurality of motors and with a light source;

Figure 2 shows a camera in another arrangement of the motors and the light source;

Figure 3 illustrates a camera with a further possible arrangement of the motors and the light source;

Figure 4 illustrates a cross-section taken along the line IV–IV according to Fig. 1 but on a different scale;

Figure 5 is a cross-section taken along the line V–V according to Fig. 1;

Figure 6 is a cross-section taken along the line VI–VI according to Fig. 1;

Figure 7 is a cross-section taken along the line VII–VII according to Fig 1.

The REES-camera shown in Fig. 1 is illustrated in a shortened version and is arranged in a tube 2. Two eccentric rings (not shown here) assure a rigid connection between the camera 1 and the tube 2, and are arranged at the front end 3 and at the distal end 4 of the camera 1; the internal diameter of the rings corresponding to the diameter of the camera 1 while their outer diameter correspond to the

internal diameter of the tube 2 and whereby respective segments are separated. Due to this separation of the segments or sections by the rings through-going passageways 5 and 6 are formed at the junctions 3 and 4, through which the cooling gas flows and the electric cables run. It is also the function of the rings to form a gap between the camera 1 and the tube 2 for allowing the camera 1 to be subjected to cooling gas. The end 8 of the tube 2 is connected to another tube (not shown) which connects the camera 1 with a manipulating device (not shown).

A pivotable mirror 10 is arranged in front of an axially movable objective 9 projecting from the tube 2. The mirror 10 is connected at the bottom via a pivot pin 11 and a protrusion 12 to a duct 13 for cooling gas and cables and at the top via a pivot 14, two levers 15, 15a and two connecting rods 16, 16a with a mirror motor 18 arranged in a tube extension 17. The rods 16 and 16a consist of a plurality of individual parts which are linked to one another by couplings 19 and 19a. A transmission 21 arranged between the rods 16 and 16a and the mirror motor 18 transmits the effect or action of the mirror motor 18 to the rods 16 and 16a. When the mirror motor 18 is switched on, the rods 16 and 16a are moved in the direction towards the mirror motor 18, causing the angle 22 between the mirror 10 and the main axis 23 to increase. When the mirror motor 18 is reversed, the rods 16 and 16a move in the opposite direction and the angle 22 decreases. The definition (sharpness) of the image or picture appearing in the monitor is adjusted by axially moving the objective lens 9 of the camera 1. The objective lens 9 is connected via two rods 25 and 25a and a transmission gear 26 to an objective motor 27 which effects axial movement of the objective lens 9. When the objective motor 27 is started or reversed, respectively, the objective 9 moves in the direction towards or away from the objective-motor 27, respectively. A lighting device is arranged in front of the objective motor 27 and consists of a halogen lamp 28, a condenser lens 29, and a reflector (not shown here). When mounting the lens 29 and the mirror 10 over the cooling gas and cable duct 13 and into the tube extension 17, care must be taken to ensure that the axis of the lens 30 and the perpendicular 31 to the mirror drawn through the centre of mirror 10 are located in one plane. The light 32, 32a, 32b emitted from the halogen lamp 28 illuminates the interior of the reactor, is reflected therefrom and the reflected light 33, 33a and 33b is guided via the mirror 10 to the objective lens 9. A 150 watt halogen lamp is used for the lighting system, the emitted thermal energy of the lamp may effect the operation of the other components arranged in the tube extension 17. For this reason, cooling gas flows through the whole apparatus during the operation of the camera and is discharged at the end 34 of the tube extension 17 and enters into the interior of the reactor through a cooling gas outlet 35. The tube extension consists of a plurality of components linked together by means of plug-in type pipe connectors 36 and 37. The electric components arranged in the tube extension 17 receive a supply of electric current by electric cables 38, 39 and 40.

The arrangement of the light source 6, the mirror motor 16 and the objective motor 27 illustrated in Fig. 2 works in principle exactly the same way as the arrangement shown in Fig. 1. Since the light source 28 is located at the end of the tube extension 17, the connecting rods 16, 16a, 25 and 25a can be arranged more simply, the mirror 10 being directly linked to the connecting rods 16 and 16a via pivot pin 14. The application of this kind of arrangement is preferred in cases in which the distance between the objective lens 9 of the camera 1 and the inspected object is large.

Fig. 3 illustrates an arrangement wherein the light source 28 is located between the mirror motor 18 and the objective motor 27. In this embodiment also there is a direct connection between the mirror 10 and the connecting rods 16 and 16a, via the pivot pin 22.

The other arrangements shown in Figs. 2 and 3 of the individual components formed in the tube extension 17 are obtained by a simple rearrangement of the modular configuration of the whole equipment located in front of the objective lens 9, wherein rearrangement may simply be achieved by means of plug-in type pipe-connectors 36 and 37.

Fig. 4 shows a cross-section along the line IV–IV according to Fig. 1 (on a different scale). This shows the tube 2, the camera 1, the end 4 of the camera, the ring 48 and the section or segment 45. The gap 6 formed by the separation of the section 45 from the ring 48 accommodates the cables 38, 39 and 40.

Fig. 5 shows a cross-section along the line V–V of Fig. 1. The arrangement of the camera 1 in the tube 2 gives rise to a gap 7 subjected to cooling gas. The cables 38, 39 and 40 are also housed in the gap 7.

Fig. 6 shows a cross-section along the line VI–VI of Fig 1, Fig. 6 has the tube 2, the camera 1 and the eccentric ring 49. The electric cables 38, 39 and 40 are arranged within the passageways 6 formed by the separation of the section 45.

Fig. 7 shows a cross-section along the line VII–VII of Fig. 1. It illustrates the condenser lens 29 arranged in the tube extension 17 as well as the halogen lamp 28 and the cables 38 and 39. The connecting rods 16, 16a and 25, 25a are also illustrated. The gap 47 serves for the throughflow of the cooling gas.

CLAIMS

1. A television camera assembly for the inspection of internal spaces in nuclear reactor plants, particularly in gas-cooled nuclear reactors, comprising a camera provided with a mirror and a light source fitted or fittable in front of the objective lens of the camera, the camera being arranged in a tube, means for permitting cooling gas from a source thereof to flow around the camera to cool it, the objective lens and/or the mirror is/are connected to a, or a respective, motor and a unit for housing the light source and the respective motor(s) are constructed as separate components, respectively, which can be joined to one another in various combinations by the application of a modular (building block) assembly technique.

2. An assembly according to claim 1, wherein the objective lens and/or mirror is or are connected via rods to the corresponding motor(s).

3. As assembly according to claim 1 or 2, wherein the motor or motors respectively and the light source are arranged in an extension of the tube.

4. An assembly according to any preceding claim wherein the tube extension is connected via a channel to the tube and is provided at its end with a cooling gas inlet.

5. An assembly according to claim 1 substantially as herein described with reference to and as shown in the accompanying drawings.

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